UNITED STATES PATENT APPLICATION

FOR

MOTION EVALUATION SYSTEM FOR GOLF SWING AND SPORTS TRAINING

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MOTION EVALUATION SYSTEM FOR GOLF SWING AND SPORTS TRAINING

This application claims the benefit of U.S. Provisional Application No. 60/404,258, "Golf Learning Aid," John Clifford Miller IV, filed on August 19, 2002, incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to the golf learning aids, and in particular to a learning aid directed to improving an individual's golf swing by monitoring spine angle during a golf swing and providing real-time feedback to the individual when the spine angle varies outside of a predetermined range of movement during the swing. The present invention further includes an audible metronome cadence to give the wearer a rhythm to improve his or her timing, golf swing and/or swing routine.

Description of the Related Art

The game of golf is hundreds of years old and there is a profusion of patents covering various technical advances aimed at improving one's golf game and lowering one's scores. Two critical factors in improving one's

golf game are learning the fundamentals of a proper golf swing, and, once learned, repeatedly practicing the golf swing to create muscle memory of the proper swing.

It is commonly accepted that a proper golf swing involves, among other things, a steady head height during the backswing through contact with the ball on the forward swing. As shown in Figs. 1 and 2, spine angle refers to the angle, θ, the spine forms with the vertical during the golf swing. The initial spine angle adopted in setting up for a golf shot will vary, depending on the club selected, the size of the golfer and the contour of the ground. However, once a golfer has addressed the golf ball and is ready to swing the club, the chosen angle should remain relatively constant through the backswing and the downward swing until contact of the golf club with the golf ball.

A common problem among golfers is to straighten up the spine angle toward vertical during the backswing and/or downswing en route to striking the golf ball. Varying the spine angle during the golf swing will often result in a "topped" or "thin" shot, where only a top portion of the ball is struck, or alternatively a "heavy" or "fat" shot, where too much of the ground behind the ball is struck. Both situations will result in a poor golf shot.

In order to regularly execute a golf swing with a proper spine angle, a golfer must first learn the proper technique and then repeatedly practice the

proper technique until the swing is engrained into the golfer's muscles. A problem however is that a golfer often does not realize that he or she is straightening up during the golf swing. Taking golf lessens where an instructor can point out spine angle movement is an effective method for detecting the problem, but golf lessens are expensive and an instructor is generally not around to detect spine angle movement when practicing the golf swing after the lesson is over. Taking video or photographic images of a golf swing is another effective method for detecting the problem, but again, this equipment is expensive and generally not convenient to carry or set up while practicing. Moreover, video and photographs are generally used after a practice session is over. They do not provide real-time assistance with swing diagnosis.

Another method for detecting spine angle deviation during a golf swing is disclosed in U.S. Patent No. 6,331,168 to Socci et al., entitled "Golf Training Head Gear For Detecting Head Motion And Providing An Indication of Head Movement." Biomechanical research has shown that there is a high correlation between spine angle and head position during the golf swing. Using this relationship, Socci discloses a system where a device is affixed to the back of a hat worn by a golfer while practicing. The device includes a sensor capable of sensing the position of a golfer's head during the golf swing, and providing an audible indication when certain

predetermined paths of head movement are detected. While the system of Socci offers certain advantages over traditional golf lessens and video equipment, improvements can be made over Socci to further facilitate detection and correction of spine angle movement to improve one's golf swing and golf game.

SUMMARY OF THE INVENTION

Embodiments of the present invention relate to a golf learning aid for improving an individual's golf swing by monitoring spine angle during a golf swing and providing real-time feedback to the individual when the spine angle varies outside of a predetermined range of movement during the swing. For this purpose, embodiments of the present invention include a learning aid device affixed to a top portion of a cap worn by the user, and an earpiece affixed to the device for playing an audible alert.

In order to generate the alert, the device includes a microcontroller and a tilt sensor. When the tilt sensor detects that a user's spine angle deviates outside of a predetermined range of movement during a golf swing, the microcontroller generates the alert. The microcontroller further employs a system of buffering and filtering to effectively eliminate motion data above and below predetermined thresholds.

It is an additional feature of the present invention that the

microcontroller generates an audible and repetitive tone as a metronome cadence when the microcontroller detects that the user is set up for a golf swing. The present invention further offers the user an option to turn off the spine angle detection features, and to use the device solely to generate a metronome cadence for improving one's rhythm and timing in the golf swing and golf swing routine.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described with reference to the drawings, in which:

FIGURE 1 is a prior art side view of a golfer preparing to swing a golf club;

FIGURE 2 is a prior art side view of a golfer during a golf swing;

FIGURE 3 is a top view of a system according to the present invention including a learning aid device mounted on a cap;

FIGURE 4 is a side view of a system according to the present invention including a learning aid device mounted on a cap;

FIGURE 5 is a front view of a system according to the present invention including a learning aid device mounted on a cap;

FIGURE 6 is a top view of a learning aid device according to the present invention;

FIGURE 7 is a top view of a learning aid device according to an alternative embodiment of the present invention;

FIGURE 8 is a block diagram of the internal components of the learning aid device shown in Fig. 6;

FIGURE 9 is a side view of a golfer wearing the system according to the present invention with an enlarged view of the tilt sensor within the learning aid device;

FIGURE 10 is a perspective view of a tilt sensor at a first angular orientation around the axis of sensitivity of the tilt sensor;

FIGURE 11 is a perspective view of a tilt sensor at a second angular orientation around the axis of sensitivity of the tilt sensor;

FIGURE 12 is a perspective view of a tilt sensor at a third angular orientation around the axis of sensitivity of the tilt sensor;

FIGURES 13A, 13B and 13C are front views of a tilt sensor according to an alternative embodiment of the present invention;

FIGURES 14A and 14B are a flow chart showing the operation of the control program according to the present invention; and

FIGURE 15 is a schematic representation of a baseline angle ± a sensitivity angle.

DETAILED DESCRIPTION

The present invention now will be described more fully with reference to Figs. 3 through 15, in which preferred embodiments of the invention are shown. The present invention may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather these embodiments are provided so that this disclosure will be thorough and complete and will fully convey the invention to those skilled in the art. Indeed, the invention is intended to cover alternatives, modifications and equivalents of these embodiments, which are included within the scope and spirit of the invention as defined by the appended claims. Furthermore, in the following detailed description of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be clear to those of ordinary skill in the art that the present invention may be practiced without such specific details.

Referring now to Figs. 3-5, there is shown a system according to the present invention comprising a learning aid device 100 affixed to a cap 102. The device may be permanently affixed to the cap 102, as by riveting or other known affixation methods. Alternatively, the device 100 may be removably affixed to cap 102, as by Velcro® or other known affixation

methods. It is understood that cap 102 may be any of a variety of hats and caps that are sufficiently snug on the wearer's head so that the cap remains stationary or relatively stationary on the wearer's head. While the device 100 is affixed to cap 102 in a preferred embodiment, it is understood that cap 102 may be omitted in alternative embodiments, in which case, the device 100 may be mounted to head gear that fits directly onto the wearer's head in a relatively stationary and secure position.

In a preferred embodiment, the learning aid device 100 is located on the cap 102 so as to be positioned on the top portion of the wearer's head when in use. It is understood that the learning aid device 100 may be located at other positions on cap 102 in alternative embodiments. Moreover, in further embodiments, the device may be worn on other locations of the wearer's body, such as the back, waist or on a vest worn by the user. As explained hereinafter, the device 100 includes a tilt sensor that is oriented generally along or parallel to the axis of the spine. It is understood that in embodiments where the device 100 is positioned at locations other than the top of cap 102, the position of the tilt sensor within the device would vary accordingly to maintain the orientation of the sensor generally along or parallel to the axis of the spine.

As seen in Fig. 4, the system according to embodiments of the present invention further includes an audio output device 104 such as an

earpiece which is affixed to the device 102 and is fashioned to be worn in the ear of the wearer. The earpiece 104 generates an audible alert in response to signals generated within the learning aid device 100 as explained hereinafter. The earpiece 104 may be coupled to the device 100 by electrical leads encased within a protective sheath. The sheath may be provided on the interior of the cap, within the lining of the cap or on the exterior of the cap in alternative embodiments. It is understood that the electrical leads and sheath may be omitted in alternative embodiments, and wireless protocols, such as for example Bluetooth wireless technology, may be used for communications between the device 100 and earpiece 104.

Referring now to Figs. 6 and 7, the learning aid device 100 comprises an outer protective housing 106 preferably formed of plastic or metal. The housing preferably includes a detachable access door 108 allowing access to the power supply for replacement or recharging of the power supply as explained hereinafter. As shown in Fig. 6, the device 100 further includes a thumbwheel 110 for adjusting the sensitivity angle of the device as explained hereinafter. As is also explained hereinafter, embodiments of the present invention further include a repetitive audible metronome cadence for swing timing. A thumbwheel 112 is provided for adjusting the tempo of the audible cadence. In the embodiment shown in Fig. 6, the volume for the audible cadence and audible alert may be

adjusted by a slide mounted on the earpiece 104. Thus, the system of the present invention may be used without disturbing others who may be nearby. In embodiments of the present invention omitting the audible cadence, as shown in Fig. 7, the volume control may be provided on a thumbwheel 114. A display window 116 may further be provided within the housing 106 in which are mounted one or more visual indicators, for example LEDs, for indicating an on/off state of the device, battery power level and other user information. On/off button 117 may additionally be provided for manually turning the device 100 on and off.

Fig. 8 is a block diagram of the components of learning aid device 100. Device 100 preferably includes a microcontroller 120, a tilt sensor 122 and a power control circuit 126 having an on/of switch 117 and controlling a power supply 128. The device 100 may further include the sensitivity thumbwheel 110 and tempo adjust thumbwheel 112.

In embodiments of the present invention, microcontroller 120 may be a microprocessor chip, such as for example the Cygnal® C8051F311. This chip includes a non-volatile program store such as a 16k byte flash memory, and volatile memory such as a RAM having 1280 bytes of on-chip data memory. It is understood that other types of microcontrollers, having other on-board features, may be used in alternative embodiments.

Tilt sensor 122 is provided for sensing absolute angular position

relative to the direction of gravity. If a golfer's spine angle changes during the golf swing so that his or her head and upper body raise upward (or lower downward), the resulting head and spine angle change is detected by the tilt sensor 122 and communicated to the microcontroller 120. In embodiments of the present invention, the tilt sensor may be an accelerometer such as the Analog Devices ADXL202E, which outputs a digital signal proportional to the angular position of the sensor relative to vertical. In one embodiment of the present invention, the microcontroller 120 samples the tilt sensor 122 one hundred forty five times a second. It is understood that the sample rate of the tilt sensor 122 may be greater or lesser than that in alternative embodiments.

Referring now to Figs. 9-12, the tilt sensor 122 has a major axis, referred to herein as the axis of sensitivity and referenced in the figures as A_S. In accordance with embodiments of the present invention, the axis of sensitivity of the tilt sensor is mounted at an angle, Φ, on the printed circuit board supporting the components within the device 100. In embodiments of the present invention, this angle Φ may be approximately 60° with respect to the printed circuit board, but it is understood that this angle Φ may be greater or lesser than 60° in alternative embodiments.

It is a feature of the present invention that, with the device fixed on a wearer's head and with the sensor oriented at the angle Φ, the axis of

sensitivity of the tilt sensor lies generally along or parallel to the axis of the spine. As the spine angle θ increases or decreases, the angle between the axis of sensitivity and vertical will also increase or decrease in same direction and in the same amount. It is understood that while the angle between the axis of sensitivity and vertical will generally match the spine angle, there may be a few degrees difference in the respective angles.

In embodiments of the present invention, the digital output of the tilt sensor received by the microcontroller will vary depending on the angle between the axis of sensitivity and vertical according to the cosine function. That is, as the angle between the axis of sensitivity and vertical varies from 0° to 90° (*i.e.*, from vertical to horizontal), the output of the sensor will go from its maximum output to its minimum output according to the cosine function. Thus, the spine angle θ may be calculated from the angle between the axis of sensitivity and vertical by the microcontroller by taking the inverse cosine of the output from the tilt sensor. The values for spine angle θ for given sensor outputs may be stored in a look-up table or calculated by algorithm. It is understood that the relationship between spine angle and the output from the tilt sensor may be other than inverse cosine in alternative embodiments of the present invention.

It is a further feature of tilt sensor 122 that it is insensitive to rotation about the axis of sensitivity. That is, for a given angle between the axis of

sensitivity and vertical, the tilt sensor will output the same voltage regardless of the angular orientation of the tilt sensor around the axis of sensitivity, which angular orientation may change as shown in Figs. 10-12. As shown in Figs. 10-12, the sensor has an axis of sensitivity A_s and a width dimension, w, perpendicular to the axis of sensitivity. The insensitivity of the sensor to the orientation of the width dimension around the axis of sensitivity is advantageous because, as a golfer swings a golf club, the golfer's head will rotate around an axis of rotation of the head and spine. This rotation will also rotate the tilt sensor around the axis of sensitivity. By aligning the axis of sensitivity along or parallel to the spinal axis of rotation as described above, the tilt sensor will be insensitive to the rotational position of the golfer's head as it rotates during the swing. Thus, a change in spine angle will at all times be indicated by a change in the angle between the axis of sensitivity and vertical, regardless of the rotational position of the golfer's head.

It is understood that the present invention may operate with sensors in which the output of the sensor is not independent of the angular orientation of the sensor around its axis. Such a tilt sensor may be used in combination with microcontroller 120 to account for the angular orientation of the golfer's head. For example, this may be accomplished with a three-axis sensor in combination with geometry processing within the

microcontroller.

It is understood that other tilt sensing devices may be used to sense the change in angle of a golfer's spine during a golf swing. A further example of a tilt sensor which is insensitive to orientation about an axis of sensitivity is shown in Figs. 13A-13C. In this embodiment, the tilt sensor comprises a sealed cylindrical container 180 having electrically insulated walls and having a conductive wire 182 extending into the center of the container. The wire 182 has a first end 184 suspended in the center of the container along the axis of rotation of the container, and a second end electrically coupled to a terminal 188. The container further includes an electrically conductive band 190, made of for example copper, extending around the interior of the container, and a conductive liquid 192, for example, a suitable electrolyte or electrolytic fluid, in the bottom of the container. The electrolytic fluid can be an ionic liquid such as water or alcohol with a small amount of salt dissolved into it. The copper band 190 has upper and lower edges that lie in planes generally perpendicular to the direction of gravity. The copper band is also electrically coupled to a second terminal 193 via a second wire 194.

When the container is upright relative to gravity, the surface of the liquid lies in contact with a lower portion of the copper band, or lies just below the copper band as shown in Fig. 13A. However, when the container

is tipped at an angle as shown in Fig. 13B, the liquid will contact a portion of the copper band. As the liquid is conductive, contact of the liquid with the copper band and wire 182 will change the resistance measured between the first and second terminals 188 and 193. As the tilt of the container increases, for example from the position shown in Fig. 13B to the position shown in Fig. 13C, more liquid will contact the copper band around the circumference of the copper band, and consequently, the resistance measured between terminals 188 and 193 will decrease further. Based on the electrical properties of the materials used, the resistance measured across terminals 188 and 193 can be correlated to an angle of the container relative to the direction of gravity. The actual angle can then be determined based on the known correlation through a look-up table or by appropriate algorithm.

By mounting the sensor 122 shown in Figs. 13A-13C on printed circuit board in a position so that the axis of rotation of the container (the axis of sensitivity) lies generally along or parallel to the axis of the spine, the sensor 122 can identify changes in spine angle as the golfer raises up or lowers down during a golf swing. As the container is circular, it will be insensitive to rotation about the axis of sensitivity.

The container sensor shown in Figs. 13A-13C for measuring a change in resistance can be converted into a sensor for measuring a

change in capacitance in the same manner by locating the copper band 190 on the exterior of the container 180 as opposed to the interior of the container. Such a capacitive sensor may also be used to sense a change in spine angle according to the present invention.

It is understood that other sensors, including other accelerometers and gyroscopes, may be used to sense spine angle in alternative embodiments.

Power supply 128 may be a conventional 3 volt lithium coin cell, however it is understood that batteries supplying more or less voltage may be used in alternative embodiments. Moreover, other power sources may be used including rechargeable batteries, such as nickel cadmium, nickel metal hydride and lithium ion batteries, and renewable batteries such as solar powered cells. Combinations of these power sources may be used as well. As indicated above, the power supply may be removed and replaced via access door 108 in the device housing 106. The voltage from power supply 128 is preferably regulated to a microcontroller voltage of, for example, 3 volts by a voltage converter.

Power to the microcontroller and other components may be controlled by power control circuit 126 and the on/off switch 117 in conjunction with microcontroller 120. In preferred embodiments, upon manual activation of on/off switch 117 to turn on the device, the power

control circuit 126 causes a voltage to be supplied from the power supply to the microcontroller and other components. It is understood that turning on of the device may be accomplished by other methods. For example, the device may include a motion sensor (which may be the tilt sensor or a separate motion sensor) which turns on the device upon sensing motion of the device. This method may operate in addition to or instead of on/off switch 117.

The device can be turned off when in an active state by activating the on/off switch 117. Alternatively, the microcontroller can turn off power supply if no motion is detected for a predetermined period of time, for example, 10 minutes.

The audio output device 104 is provided to output an audible tone to the wearer. It is understood that in alternative embodiments, other indicators capable of generating perceptible indications of an alert and/or a metronome cadence as described hereinafter may substitute for the audio output device 104. Such alternative indicators may include visual indicators and pressure indicators that apply light, perceptible contact to an area of the user's body. The indicators may additionally or alternatively provide a perceptible indication by buzzing and vibration.

Device 100 is fabricated, tested and calibrated first by assembling the microcontroller and other device 100 electronics onto a printed circuit

board and then performing electrical testing of the circuit board for example on an in-circuit test (ICT) fixture. Thereafter, microcontroller is connected to a computer and the control program is downloaded from the computer to the microcontroller non-volatile memory. The control program, explained in greater detail below, includes a calibration subroutine for calibrating the offset and gain of the tilt sensor signal. In preferred embodiments, the tilt sensor (mounted at an angle on the printed circuit board) should be horizontal during the calibration process.

The operation of the control program loaded in the non-volatile memory will now be explained with reference to the flow chart shown in Figs. 14A and 14B. After the device is turned on in a step 200, for example by manual activation of switch 117, the device goes into a ready state in step 202. From the ready state, the microcontroller performs two processes concurrently. In one process, shown in step 204, the microcontroller continuously monitors whether a predetermined period of time has passed where there has been no activity. The microcontroller includes a clock that monitors the passage of time. The control program continuously loops between steps 202 and 204. If at any time the microcontroller detects the passage of a preset time period, for example 10 minutes, without any activity, then the control program jumps out of the loop and the device is shut off in a step 206.

Concurrently with the timeout check, the control program causes the microcontroller to determine the current spine angle θ (Fig. 9) indicated by the angle between the axis of sensitivity and the vertical in a step 208. The microcontroller 120 receives a digital signal from the tilt sensor 122 relating to spine angle one hundred forty five times a second (in one embodiment). Six sensor samples may be averaged and resampled at twenty times a second. The actual angle may be calculated from a look-up table or algorithm as described above according to the inverse cosine of the sensor 122 output.

The control program according to the present invention includes a data smoothing process as part of step 208. In particular, if the spine angle changes dramatically from one sensor sample to the next, this is the result of bouncing, shuffling or fast motion other than a golf swing, and this data should be disregarded. In order to accomplish this, the control program causes the microcontroller to examine changes in spine angle between consecutive sensor samplings for the most recent nine spine angle entries stored in RAM. The microcontroller performs an eighth order low pass filter on the angle data. The low pass filter attenuates angle changes that occur above a predetermined frequency, for example above 7 Hz. This information is then stored as a 32-entry LPF buffer within the microcontroller RAM. It is understood that the microcontroller may use

more or less that the most recent nine data entries, and may filter out data greater than or lesser than 7 Hz, in alternative embodiments.

If someone wearing the device is walking or standing in an upright position, the device 100 should not be monitoring for proper spine angle. Likewise, if the wearer is bending over, for example picking up a golf ball or other item, the device 100 should not be monitoring for proper spine angle. Therefore, in step 210, the control program determines whether the spine angle θ is between a predetermined maximum and minimum angle corresponding to a possible ready position for swinging a golf club. In one embodiment of the present invention, the minimum spine angle can be between 5° and 15° and optimally around 10°, and the maximum spine angle can be between 70° and 90° and optimally around 90°. It is understood that the minimum and maximum spine angles can be outside of the respective ranges set forth above in alternative embodiments. If the current spine angle is not within the minimum and maximum angles, the control program returns to the ready state 202.

In a step 212, the control program next checks to see whether motion is below a threshold level. In particular, if the user of the device is moving around above a threshold level, he or she is not ready to perform a golf swing, and the device should not move to the armed state. In order to check for motion above a threshold level, the control program causes the

microcontroller to examine changes in spine angle between consecutive sensor samplings for the previous 32 entries stored in the RAM LPF buffer. The microcontroller performs a second order high pass filter on the angle data in a 32 entry high pass filter buffer in RAM. The high pass filter attenuates angle changes that occur below a predetermined frequency, for example below 0.33 Hz. The control program then sums the absolute values of the previous 32 entries in the high pass filter buffer. If the sum is above a predetermined limit, this indicates spine angle movement above the threshold level, and the control program returns to the ready state in step 202. If the sum of the angle changes is below the predetermined limit, this indicates movement below the threshold level and the program proceeds to a step 214. In a preferred embodiment, the limit may vary from 22.5° to 50° depending on the current spine angle. It is understood that the high pass filter may be set to filter data above or below 0.33 Hz, and that the predetermined limit may be set above or below 22.5° to 50°, in alternative embodiments.

In embodiments of the present invention, it is desirable to build in a delay after an alert sounds to ensure that the action giving rise to the alert has been completed and multiple alerts do not sound as a result of a single action. The control program therefore builds in a delay after an alert has sounded in a step 214. Once an alert has sounded, the time of the alert is

stored in the microcontroller RAM. In step 214, the control program checks to see if the predetermined period of time since the last alert has passed. In one embodiment, that period of time may be 4 seconds, but the delay period may be greater than or less than 4 seconds in alternative embodiments. If the time since the last alert is less than the predetermined period of time, the control program returns to the ready state of step 202.

If each of steps 210 through 214 are passed, that indicates that the wearer is set up for a golf swing. Accordingly, in a step 216, the control program causes the current spine angle to be set as the baseline angle, ψ, as shown in Fig. 15. The baseline angle is used as the spine angle to be maintained during the ensuing golf swing. If the spine angle deviates from the baseline angle greater than a user-defined angular range, as explained hereinafter, the alert will sound. The control program allows the baseline angle ψ to vary from swing to swing, which is desired because the baseline angle for a given swing will depend on several factors which can vary from swing to swing, including the club selected and the incline of the ground on which the swing is being performed.

Referring still to Fig. 15, the present invention allows a wearer to select an angle, referred to herein as the sensitivity angle α, which is added to the baseline angle Ψ and subtracted from the baseline angle Ψ to define a maximum spine angle range for the golfer's spine during a golf swing. If

the golfer deviates outside of the maximum spine angle range during a golf swing, the alert will sound. The sensitivity angle α may be set via thumbwheel 110. The sensitivity angle α is selected based on the wearer's skill level. Relatively unskilled golfers who have not yet learned a consistent swing would want to set a relatively large sensitivity angle α to provide a large maximum spine angle range. Thus, they can execute a golf swing where their spine angle does vary somewhat, but allows them to practice and improve without the alert sounding on every swing. The alert would only sound when their spine angle is outside of the maximum spine angle range given by the baseline angle, Ψ, plus and minus the sensitivity angle α they selected. On the other hand, relatively skilled golfers would want to set a relatively small sensitivity angle so that their spine angle must stay relatively constant or the alert will sound. In embodiments of the invention, the sensitivity angle may be set to as little as 4° and as high as 21°. Thus, when set at the minimum sensitivity angle, if the wearer deviates his or her spine angle from the baseline angle more than 4° upwards or more than 4° downward, the alert will sound. Similarly, when the maximum sensitivity angle is selected, if the wearer deviates his or her spine angle from the baseline angle more than 21° upwards or downwards, the alert will sound.

It is understood that the maximum and minimum sensitivity angles

may be greater or lesser than 4° and 21°, respectively. Moreover, it is understood that manual controls may be provided on the device (not shown) to provide a maximum spine angle range that is not symmetrical about the baseline angle Ψ. For example, controls may be provided to allow a golfer to raise up toward vertical as much as 21° above the baseline angle without the alert sounding, but lower down only 10° below the baseline angle without the alert sounding. Thus, the maximum spine angle range is 30°, but it is not symmetrical about the baseline angle. The device may also be configured to allow a greater motion below the baseline angle than above the baseline angle.

Once the baseline angle is set in step 216, the device 100 goes into an armed state in step 218. When in the armed state, it is a feature of the present invention to sound a metronome cadence. The metronome cadence is an audible tone generated by the microcontroller 120 and played through the earpiece 104. In addition to alerting the wearer that the device 100 is in the armed state, the tone is intended to give the wearer a cadence and rhythm to improve his or her timing, golf swing and/or swing routine. The tempo of the metronome cadence may be user adjusted via thumbwheel 112. In embodiments of the invention, the cadence may be as slow as 45 beats per minute and as fast as 95 beats per minute. The tempo of the cadence may vary outside of that range in alternative

embodiments of the invention.

There can be a setting on thumbwheel 112 or some other actuator located elsewhere on the housing 106 which, when selected, turns off the spine angle detection features of the device 100. When used in this mode, the device 100 continuously sounds the metronome cadence which can be played while practicing or playing a round, and used with woods, irons and while putting. When in this mode, the metronome cadence would continue to sound until turned off by the wearer.

Once in the armed state, in addition to sounding the metronome cadence, the microcontroller performs two additional processes concurrently. In one process, shown in step 220, the microcontroller continuously monitors whether a predetermined period of time has passed where there has been no activity. The control program continuously loops between steps 218 and 220. If at any time the microcontroller detects the passage of a preset time period, for example 10 minutes, without any activity, then the control program jumps out of the loop and the device is shut off in a step 222.

Concurrently with the timeout check, the control program executes a step 224 where the microcontroller determines a current spine angle (as described above with respect to step 208), and determines whether the current spine angle is outside of the maximum spine angle range given by

the baseline angle plus and minus the sensitivity angle as described above. If so, then the control program causes microcontroller 120 to sound an audible alert through the earpiece 104 in a step 226. The alert may differ in tone and/or duration from the metronome cadence. The duration of the audible alert may vary, but may be for example 1 second. In the above-disclosed embodiment, the alert is sounded when the wearer's spine angle either increases or decreases from the baseline angle Ψ greater than the sensitivity angle α. However, in alternative embodiments, the system may monitor only when the baseline angle decreases greater than the sensitivity angle (*i.e.*, the system only checks to see if the golfer rises up a certain amount during the golf swing). Alternatively, the system may be set up to detect only when the baseline angle increases greater than the sensitivity angle.

If the spine angle detected is outside of the maximum spine angle range in step 224, the metronome cadence may be turned off in a step 228. It is understood that in alternative embodiments, step 228 may be skipped so that the metronome cadence stays on even if the alert sounds. This alternative is a separate embodiment from an embodiment where the user has selected the mode where the spine angle detection system is turned off and the device functions solely as a metronome cadence system.

After performing steps 226 and 228, the control program returns to

the ready state in step 202. If the spine angle detected in step 224 is within acceptable ranges, then steps 226 and 228 are skipped, and the control program loops back to the armed state in step 218.

As is evident from the above-description, the present invention may be used as a learning aid to provide real-time feedback to improve one's golf game. In use, a wearer would initially set the desired sensitivity angle, the tempo for the metronome cadence and/or the volume of the alert and cadence. Then the wearer would go about his or her normal practice routine. The device can be used to provide both cadence and spine angle monitoring. Alternatively, when used only in metronome cadence mode, the device can provide a repetitive tone for improving one's rhythm and timing.

Although the invention has been described in detail herein, it should be understood that the invention is not limited to the embodiments herein disclosed. Various changes, substitutions and modifications may be made to the disclosure by those skilled in the art without departing from the spirit or scope of the invention as described and defined by the appended claims.